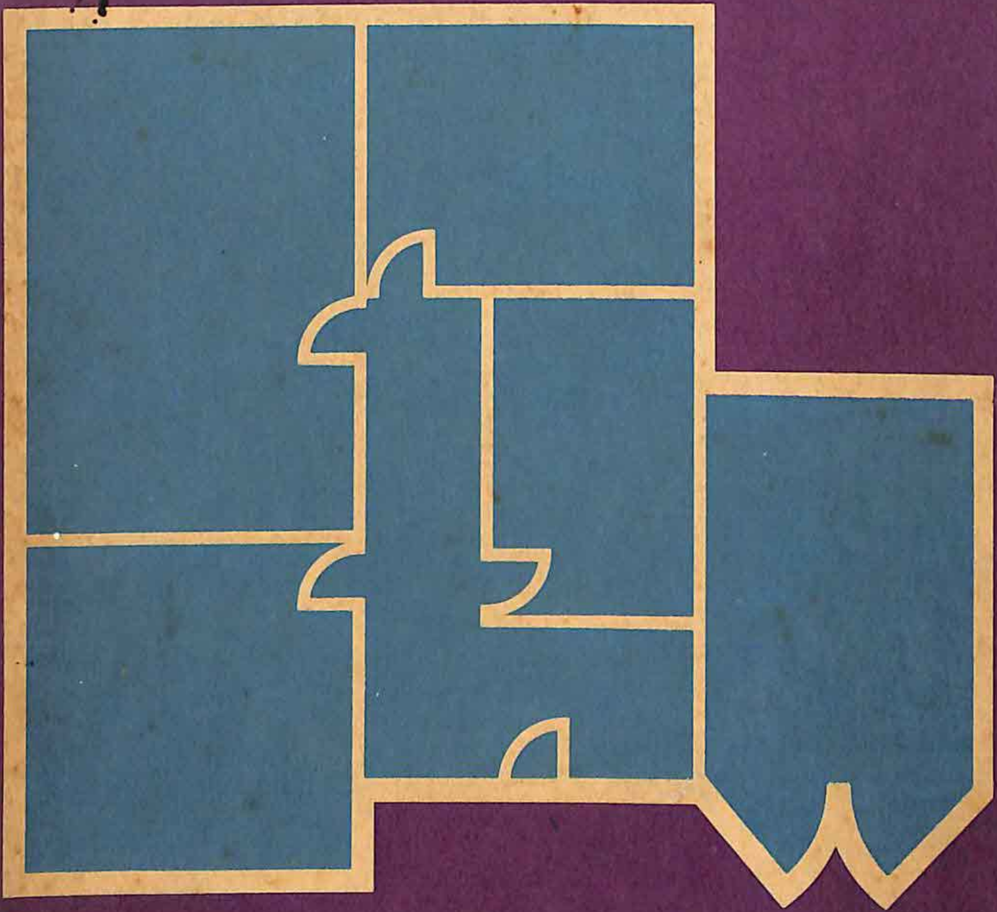
Mathematics in the Making 6

Scale Drawing and Surveying

Stuart E Bell



Longmans

Mathematics in the Making

Scale Drawing and Surveying

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Stuart E Bell
Headmaster
Whipton Barton Junior Mixed School
Exeter

in collaboration with
the School Mathematics Project
at Exeter School

Deputy Director of Public Instruction
(Planning), West Bengal

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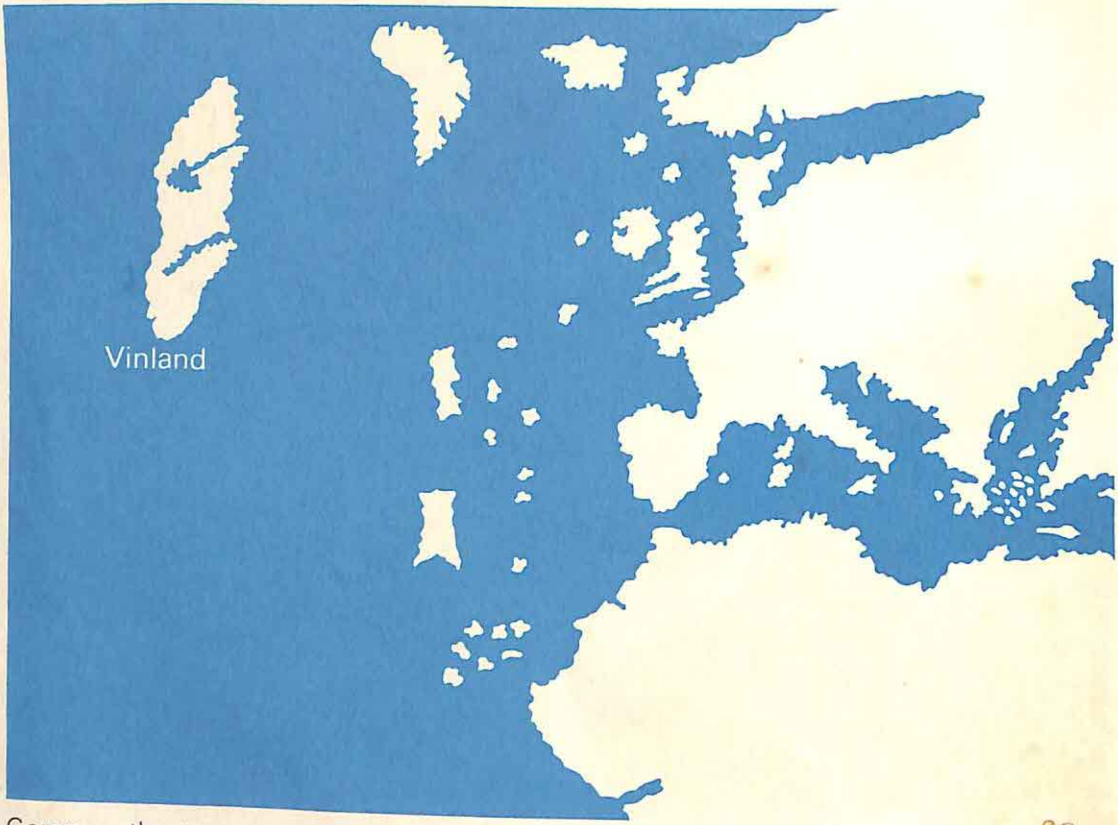
Scale Drawing and Surveying



Compare the two maps on these two pages.

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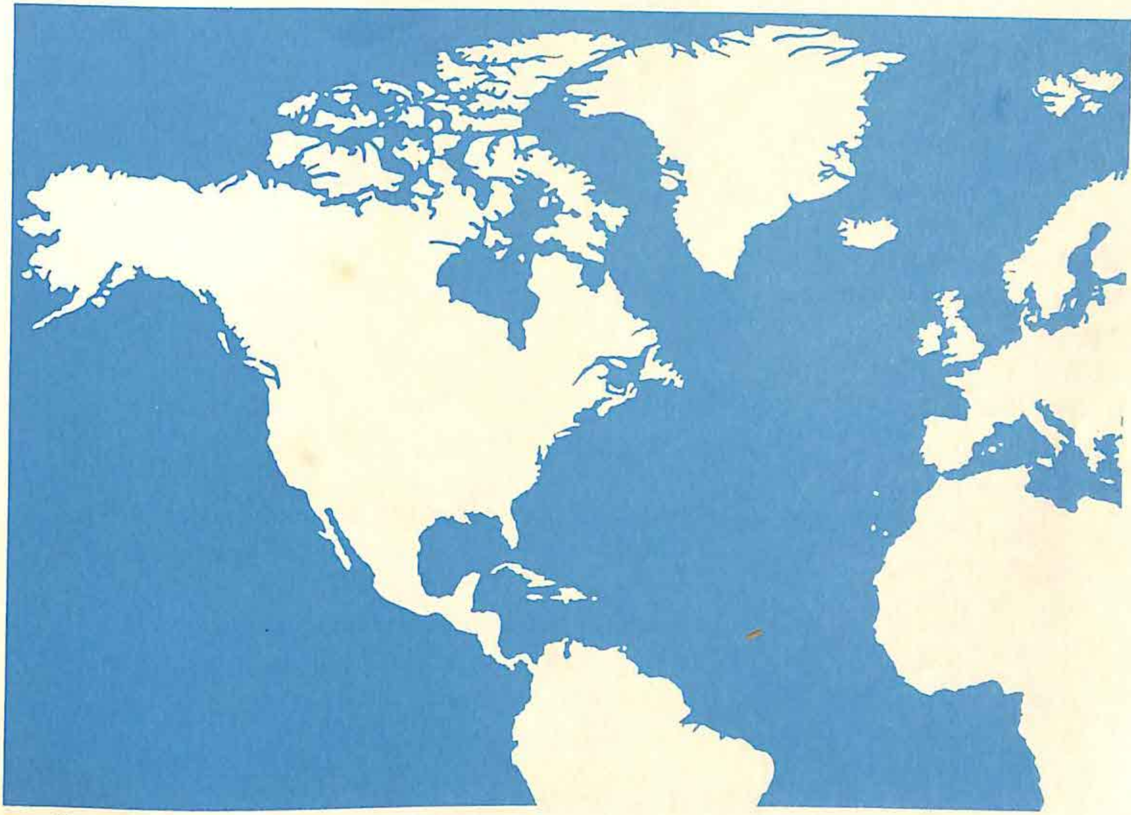
They each represent the same part of the world. The first one is about eight hundred years old. It shows the world as it was known to the Norsemen. It is the oldest known map of North America, which they called Vinland, and proves that the Norsemen sailed there four hundred years before Columbus.

Notice how different Vinland is in shape from that of North America on the modern map.



Which other countries look very different?

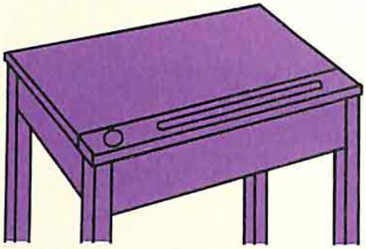
Which map is more accurate? Why do you think this is?

The Norsemen did not have the use of modern instruments to measure distances and their knowledge of mathematics was very small.

In this book you will learn how to make accurate maps and plans.

Maps and plans are usually drawn as they appear from above—a bird's eye or a space man's view.

Would your desk look like this if you were directly above it?



A PLAN of this desk would only show the top.

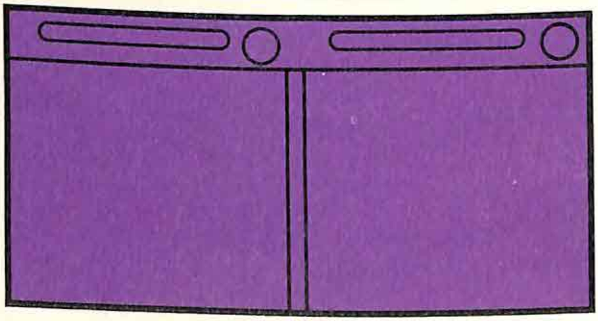
What shape would it be?
Make a rough plan of your desk.
Compare your plan with those drawn by your neighbours.
Are they exactly alike?

It is quite likely that the plans vary considerably, some making the desk appear narrower and others making it look broader. You have only made a guess at the shape and have not thought about the measurements. This is probably what the Norsemen did.

Scale Drawings

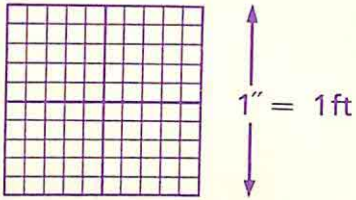
Now look at this plan of a desk.

Every inch on this plan is equal to 1 foot on the desk



Measure the length of the desk in inches.
What is the actual length of the desk?
Can you discover the width?

Make a plan of a desk which is 4 feet long and 2 feet 6 inches wide on graph paper using 1 inch for every foot on the desk.



Can you now make a plan of your own desk in the same way? When you measure it you will probably find that the length and breadth are in feet *and* inches. What will you do with the inches on your plan?

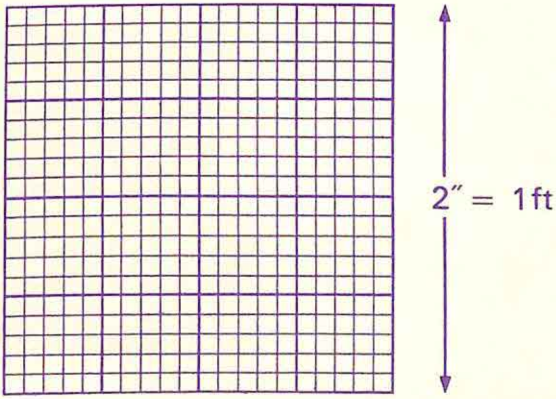
One easy solution is take the measurement to the nearest quarter of a foot: e.g. call 4 feet 1 inch, 4 feet; and 4 feet 8 inches, 4 feet 9 inches, etc.

Compare your completed plan with the desk.
Does it look the same shape now?

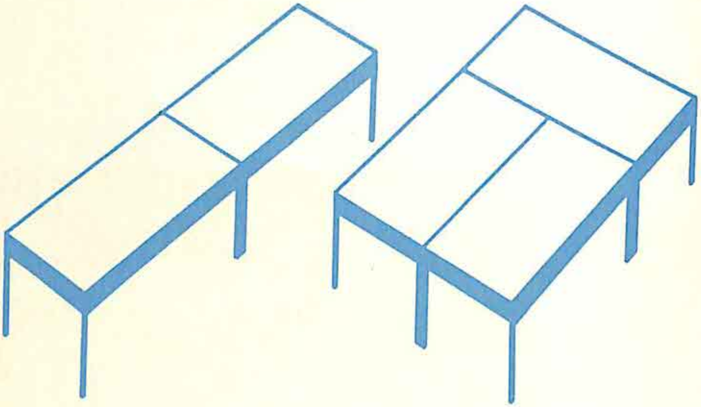
You have now made a SCALE DRAWING of your desk. The scale you used was 1 inch to every foot.
The map on page 3 is also drawn to scale which is 1 inch to every 2,000 miles.

Draw your desk on a scale of 2 inches to every foot. Compare it with your first scale drawing. Do they both look the same SHAPE?

Can you discover other scales suitable for drawing a plan of your desk? What is the largest scale you can use on your graph paper?



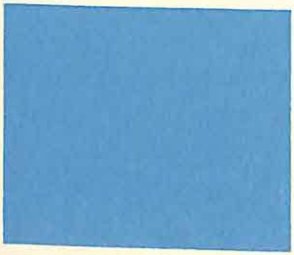
Put two, three or four desks together. Choose a suitable scale and make scale drawings of the new shapes you have made.



You can also make a scale drawing of your teacher's desk and other classroom furniture, such as tables.

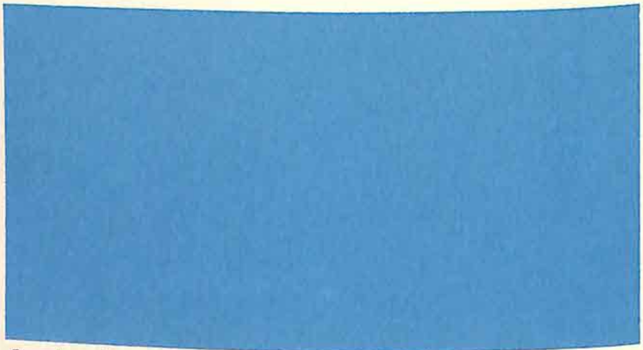
Find the actual lengths and breadths of the tables in these scale drawings:

A



Scale: 1 inch to every 2 feet

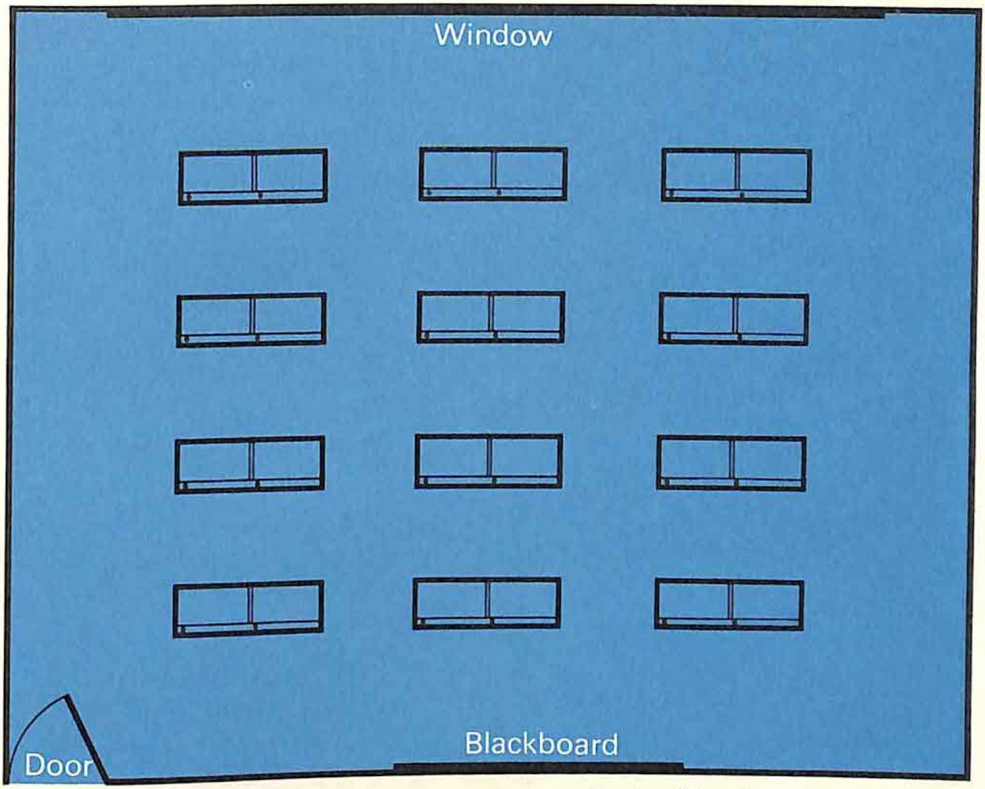
B



Scale: 1 inch to every 4 feet

Here is a scale drawing of a classroom.
The scale is smaller than the ones you have used previously.

Why is this?



Scale: 1 inch to every 5 feet.

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CAN YOU FIND THE FOLLOWING:

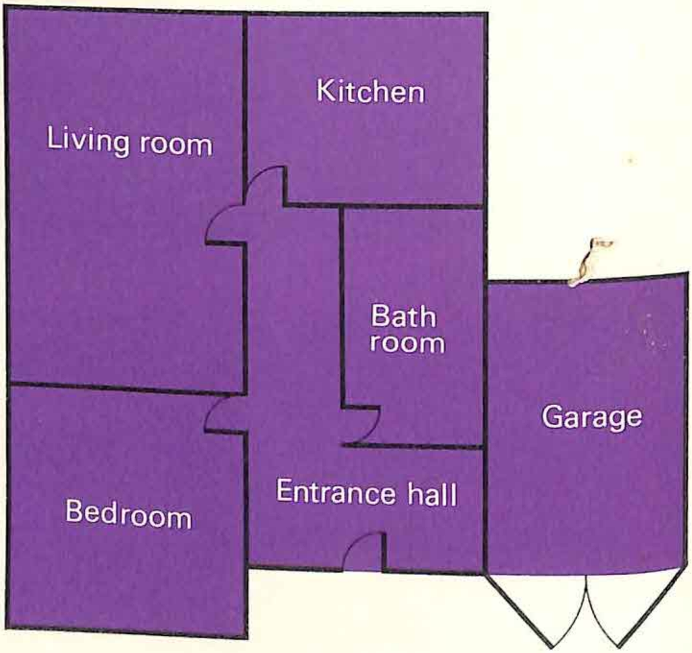
1. The length of the classroom.
2. The width of the classroom.
3. The length of each desk.
4. The distance between each desk.
5. The width of the door.
6. The length of the blackboard.
7. The distance of the blackboard from the door.
8. The length of the window.

You can now make a scale drawing of your own classroom.

First measure its length and breadth.
You must now decide on a scale which will suit your graph paper or exercise book. Try to make the drawing as large as possible. Ignore any inches which may be left over.
Draw the door and blackboard to scale.
Can you fit in your desk?

Perhaps you can make a scale drawing of your hall or a room at home.

Here is a scale drawing of a bungalow.
You can see which way the doors open.



Scale: 1 inch to every 12 feet

FIND OUT:

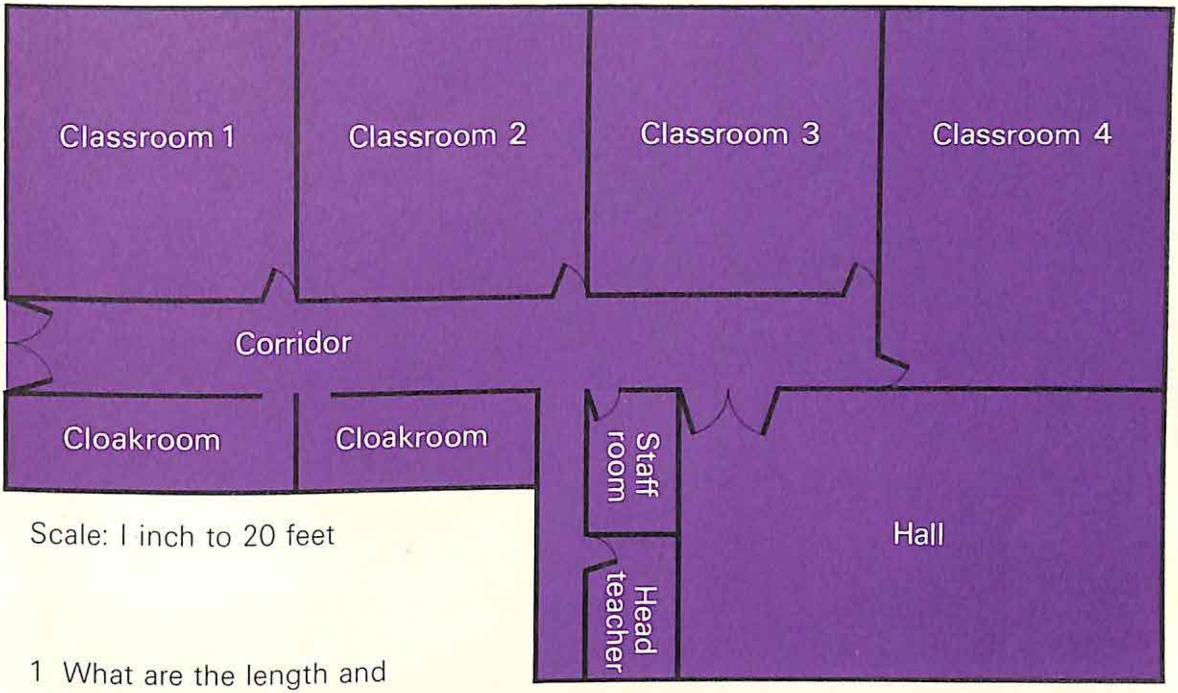
1 How long is the living room?

2 Would a car that is 17 feet long fit into the garage?

3 How much would it cost to cover the bedroom floor with carpet costing 5/– per square foot?

4 Would it be possible to make a serving hatch between the living room and the kitchen?

This is a scale drawing of a school.



Scale: I inch to 20 feet

1 What are the length and breadth of the largest classroom?

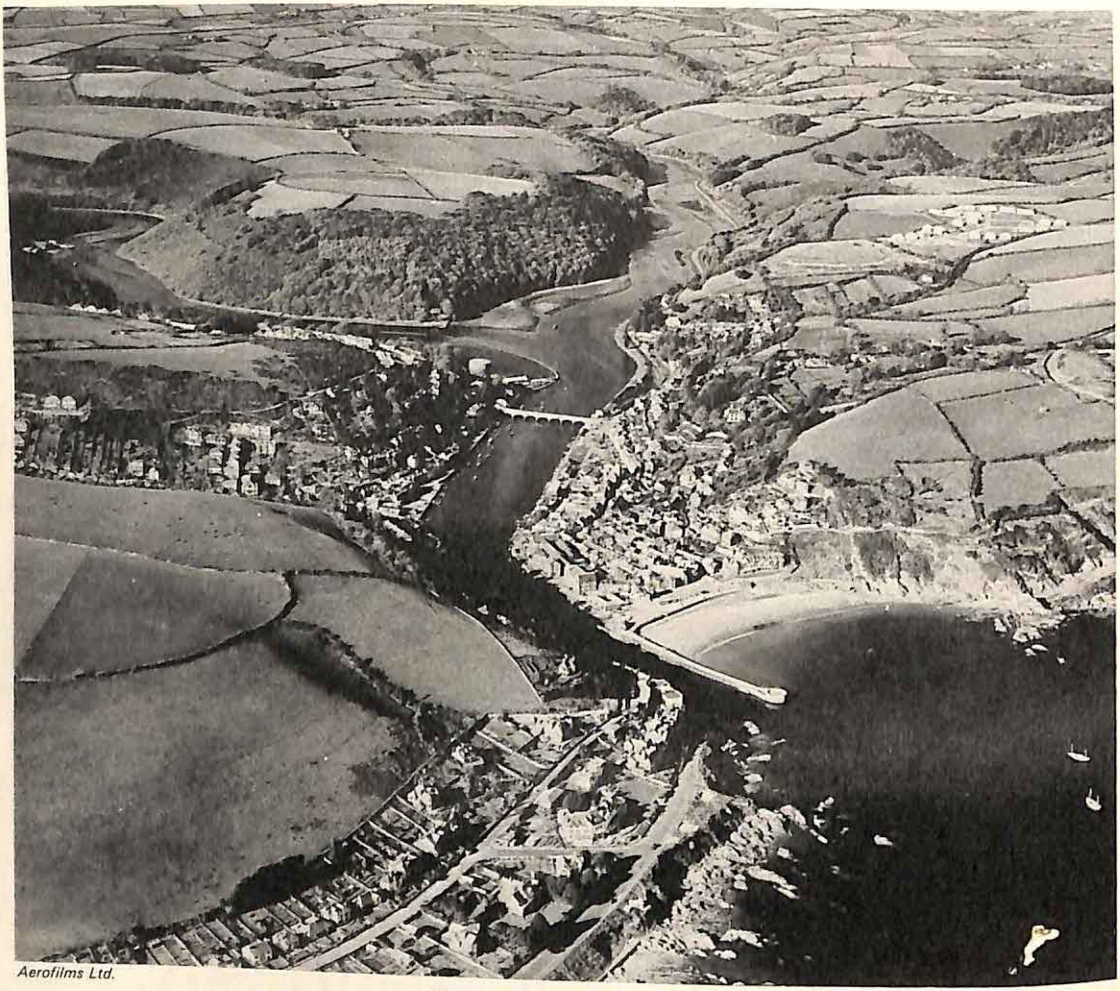
2 Find the area of each of the smaller classrooms.

3 How long is the corridor?

4 A badminton court is 44 ft long and 20 ft wide. Is there sufficient space in the hall to make a court?

5 Which classroom door is nearest to the cloakrooms?

6 A grand piano has been given to the school. The piano is 6 ft wide and 7 ft in length. Can it be wheeled into the hall from outside?



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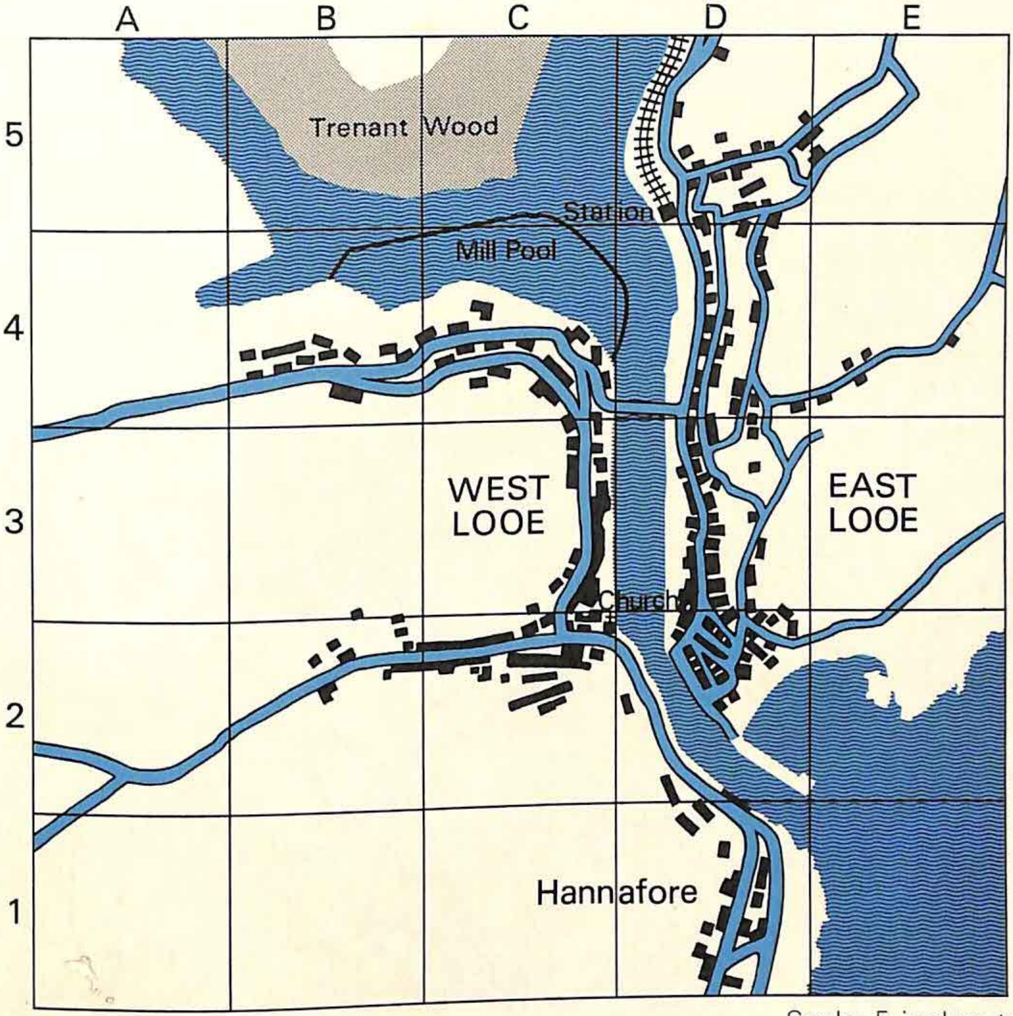
Here is a photograph taken from an aeroplane of the seaside town of Looe in Cornwall.
On the opposite page is a map of the same area, drawn to scale.

Compare the map and the photograph.
Find the following on both:
the pier;
the main beach;
the bridge over the river;
Trenant Wood.



Scale: 5 inches to 1 mile

CALCULATE THE APPROXIMATE DISTANCE by road between the following:

1 The end of the pier and the station.

2 West Looe church and the station.

3 The centre or Hannafore and the pier.

If you live in or near a town you may be able to obtain a town plan on which you can find places that you know and work out distances.

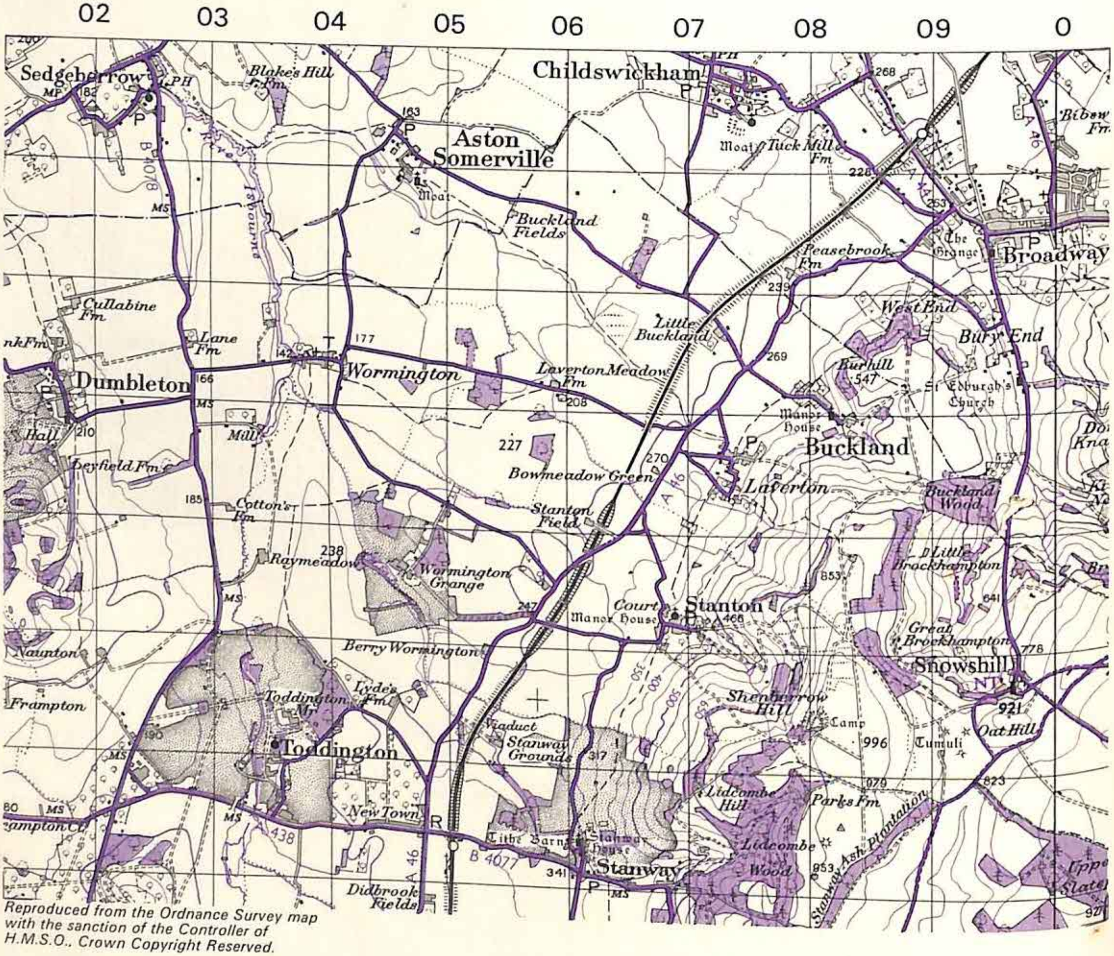
Here is a section of the popular Ordnance Survey map. Drawn to a scale of 1 inch to every mile, maps like these cover the whole of Great Britain. They are most useful for cycling and walking, as they show foot paths as well as roads. If you examine the map you will find many interesting things, such as a tithe barn. The key will help you to find the meaning of some of the signs.

═ Roads

— Railway

• • Churches

▨ Wood



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FIND THE FOLLOWING:

1 The distance as the crow flies (direct) from
a) Toddington to Wormington
b) Sedgeberrow to Broadway.

2 The distance between each pair of villages by road.

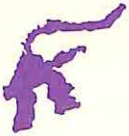
3 The distance by rail from the station near Stanway to the station near Broadway.

Study the 1″ map of your own area and calculate the distance between places.

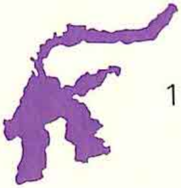
If you examine an atlas you will discover that several different scales are used.

Make a list of scales from your atlas and arrange them in order, with the smallest scale at the top and the largest at the bottom.

Here are two maps of an island, drawn to differen scales.



1 inch to 800 miles



1 inch to 600 miles

Do they look the same shape?

USE YOUR ATLAS TO CALCULATE THE FOLLOWING DISTANCES as the crow flies:

1 London to Glasgow.
2 Edinburgh to Plymouth.
3 London to Paris.
4 London to Cardiff.
5 London to New York.

Your answers will only be rough because the world is, of course, round, and not flat as it is shown in an atlas.

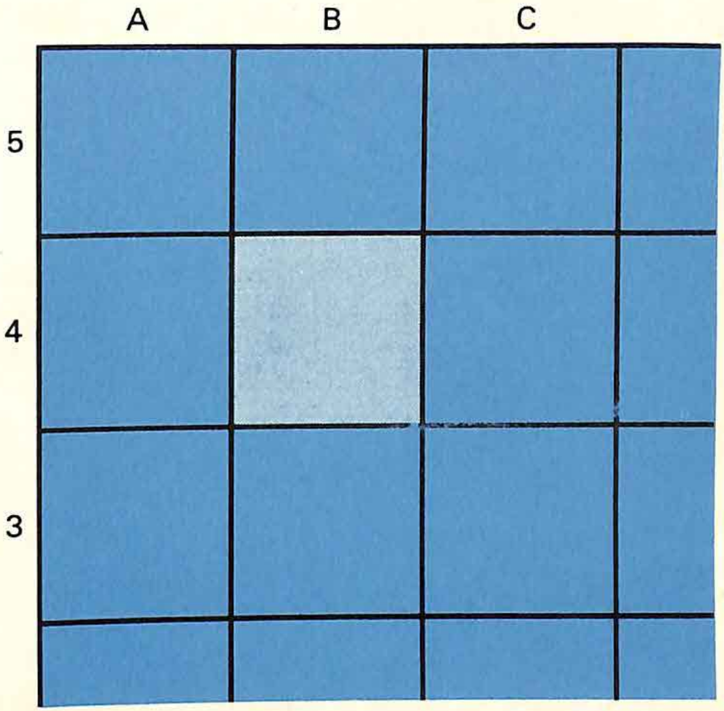
If you have a globe you may be able to make a more accurate estimate.

Map References

The plan on page 11 is divided into large squares. This is often done on town plans to help you to find a street quickly.

Each column has a letter which is also given to each square in that column.

Each row has a number which is also the number of each square in that row.



The shaded square is B4.

Find a square on the map. Give its letter and its number.

The town plan also contains an alphabetical list of streets and their map references, such as:

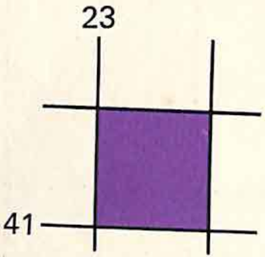
River Street	C3
Rosebank Terrace	D4
Roundhill Crescent	A6
Russell Square	B5

GIVE THE MAP REFERENCES OF THE FOLLOWING which are on the map on page 11:

1 the pier;
2 the bridge;
3 the station;
4 Mill Pool.

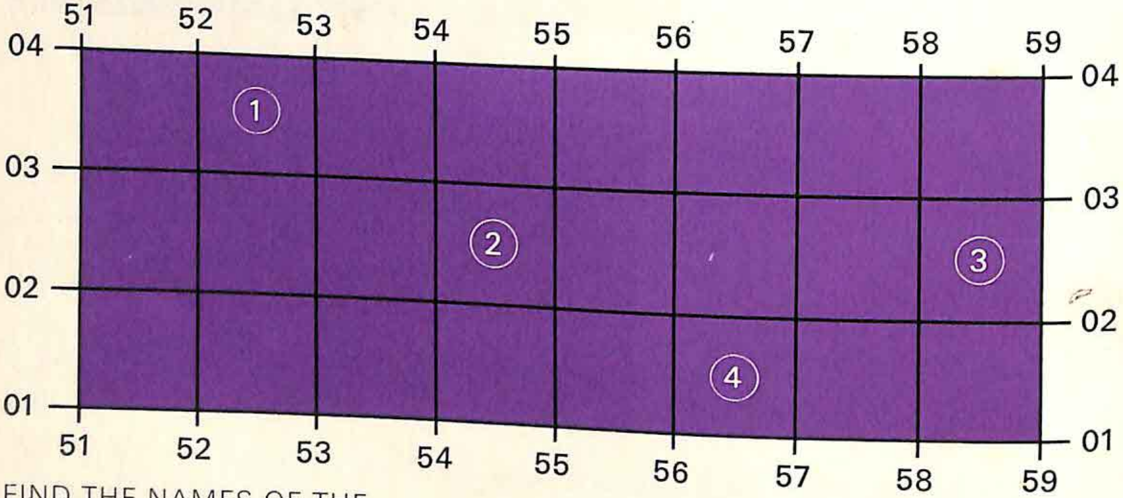
The 1″ map on page 12 is also covered with small squares, but these are numbered and not lettered.

Notice that the numbers are opposite the lines and not the squares.



The reference number of this square is 23 41 because the lines 23 and 41 meet at the bottom left hand corner of the square.

Give the reference numbers of the numbered squares. Remember to read across first.

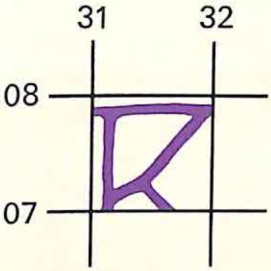


FIND THE NAMES OF THE VILLAGES in the following squares on the map on page12:

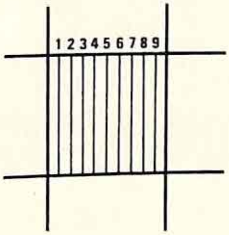
A 0735
B 0738
C 0634
D 0933

You will see that this is an easy and accurate method of describing the position of such landmarks as villages, lakes and woods on a map. But it is not sufficient for finding smaller points. Suppose you arranged to meet a friend at the junction in square 3107.

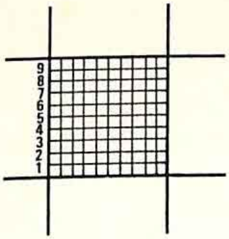
Which one would you choose?



In a case like this it is necessary to give a more detailed map reference.



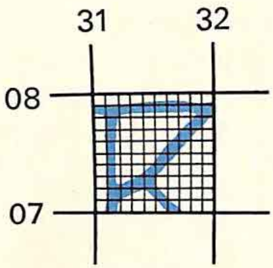
This square has been divided into ten columns.



Now ten rows have been added.

The lines are numbered from 1 to 9 in each direction.

It is now possible to use these figures in addition to the numbers of the square.



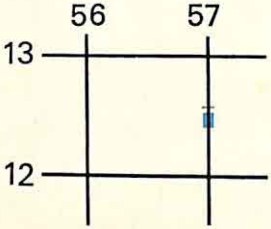
The road junctions have reference numbers as follows:

311078, 319078, 311071 and 314072.

These are called 6-figure map references and are the ones we usually use on the 1″ map. But the maps are not divided into these tiny squares which would cover up most of the detail on the map. It is necessary to estimate the distance across each square as a number.

This is not difficult if we think of the half-way point in each direction as 5.

Can you give the map reference of this church? Remember there must be 6 figures.



FIND THE OBJECTS OR LANDMARKS at the following map references. They are all on the map on page 12.

A 069370
B 097363
C 034358
D 045335

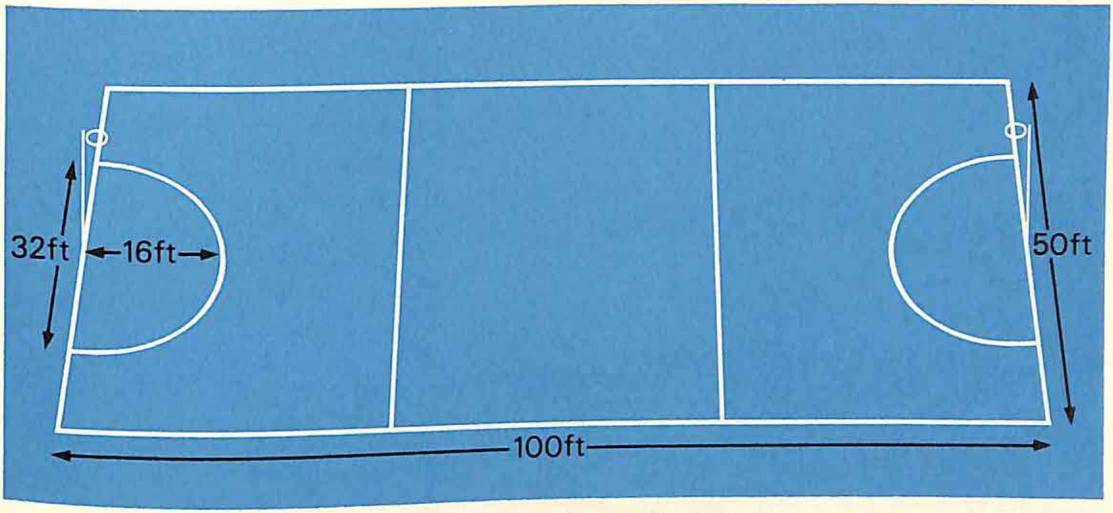
GIVE THE 6-FIGURE MAP REFERENCES OF THE FOLLOWING:

1 Toddington church;
2 Broadway Station;
3 the top of Oat Hill, which is 2½ miles South of Broadway;
4 the church at Stanton.

Surveying

You have learned how to make scale drawings of rooms with straight sides.

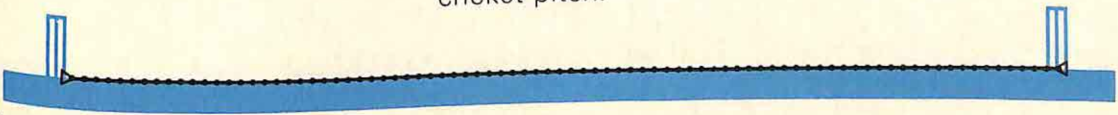
Choose a suitable scale and make a plan of this netball court.



The court is divided into thirds.

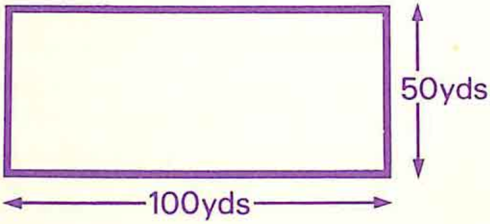
Can you make a scale drawing of your playground or a football pitch? What will you use to measure the sides?

The instrument most commonly used for measuring distances outside is the Gunter's chain. This is 66 feet long, just as long as a cricket pitch.

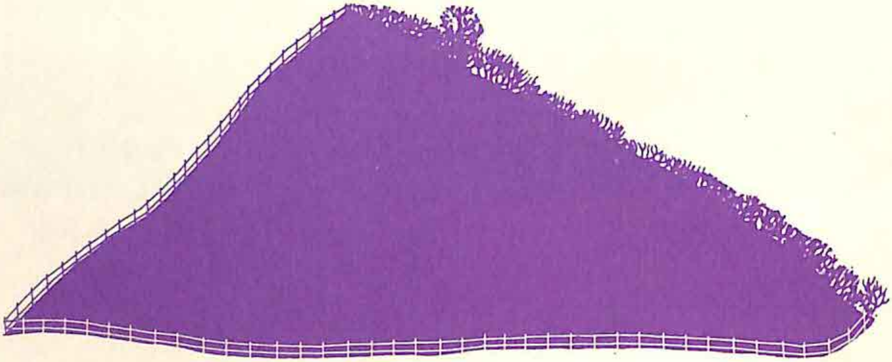


Will you measure in feet or yards?

You will find it helpful to make a rough sketch of the playground or pitch while you are outside and to write the measurements along each side, like this:



Supposing you were to make a scale drawing of a field, such as a school playing field. It is possible that the field will not be in the shape of a rectangle like the netball and football pitches. It might have a shape like this:



Let us ignore the bends for the moment.

If poles were placed in each corner and joined by string, what shape would be formed?

The men who make maps and plans out of doors are called surveyors and this is the method which they use.

They measure the main shape formed by the lines which are known as survey lines. Then they measure the distance between the boundary and the lines.

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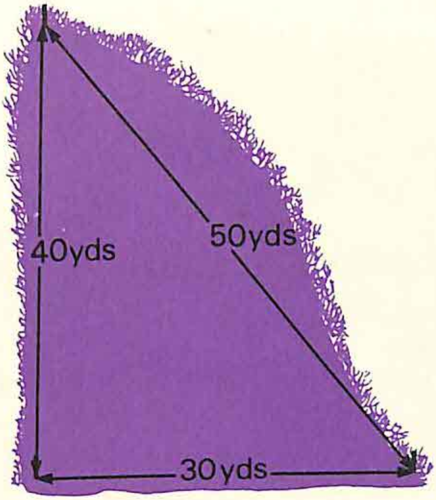
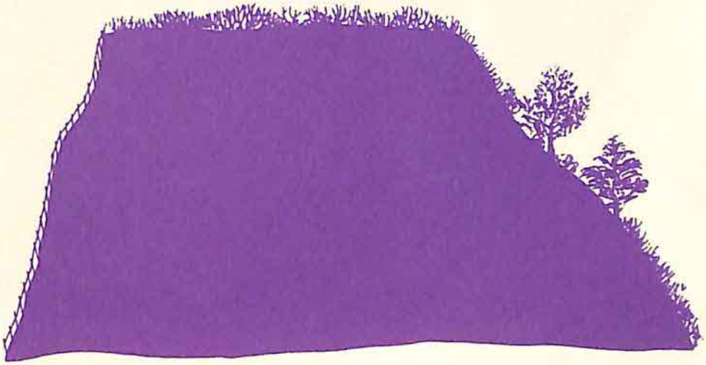
In this diagram the survey lines are drawn.



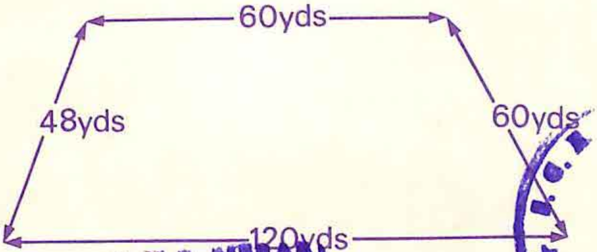
Can you make a scale drawing of the field?
Start by drawing a plan of the shape made by the survey lines.
Do you need to know the angles?
A clue: Use a pair of compasses.
Complete your scale drawing by drawing the boundary around the survey lines.

This field has a different shape:



If survey lines were drawn from each corner what would be the shape that was formed?
Supposing you were to make a scale drawing of this field. Is it enough to know the length of the four sides?
Try to discover this.

The lengths of the survey lines can be seen here.



Compare your scale drawing with others made in the class.
Are they all exactly alike?

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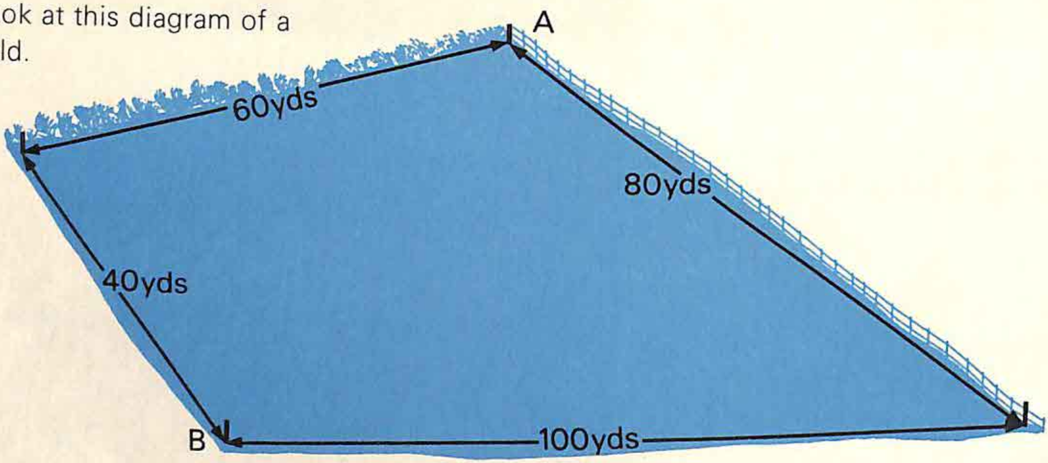
You have discovered that you can make a scale drawing of a triangular field if you know the lengths of the sides but that it is not sufficient to know the lengths of the sides of a four-sided field.
What else do you need to know?

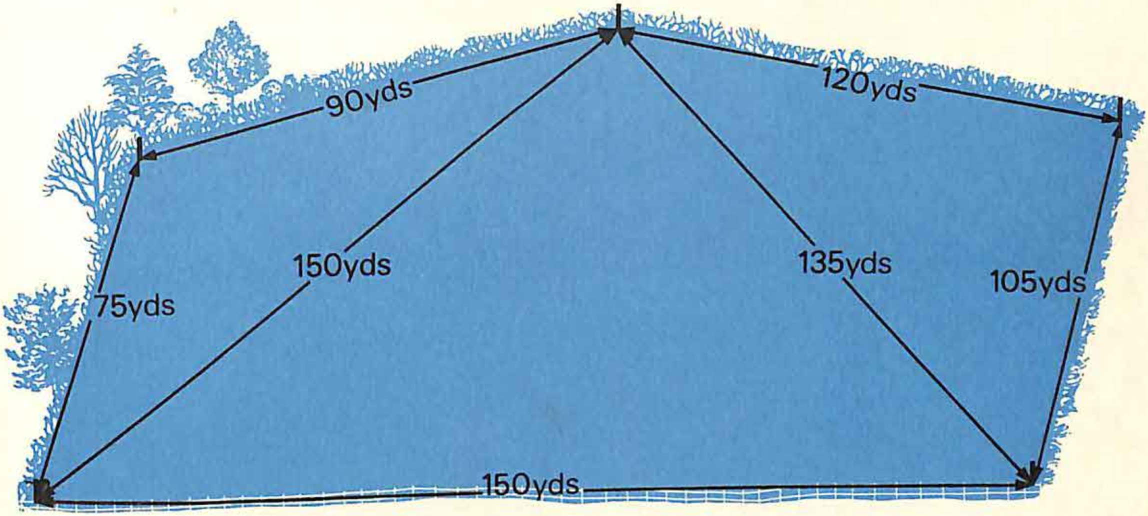
You will learn later how surveyors measure angles, but there is a method of drawing this plan accurately without using the angles.

Look at this diagram of a field.



If you were to draw a survey line from A to B, what shapes would you have made? Could you now draw the field to scale? Try to do this. The distance from A to B is 60 yards. Think carefully about which line you should draw first. Does it matter which one you use?

Here is a field with five sides.

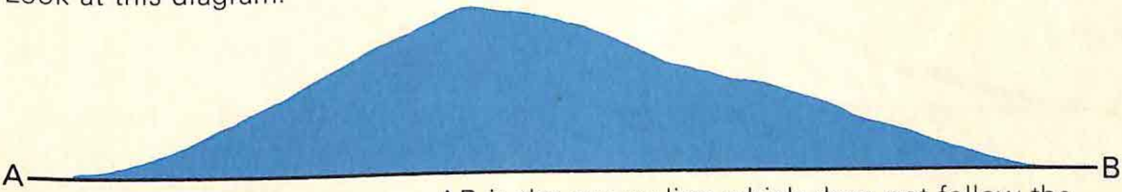


Can you use a similar method to make a scale drawing?
How many triangles will you draw? Use a scale of 1 inch to 15 yards.

Make a scale drawing of the survey lines of a field near your school using the triangle method which you have been shown.

You will then have to find out how to draw the boundaries of the field if these are not straight.

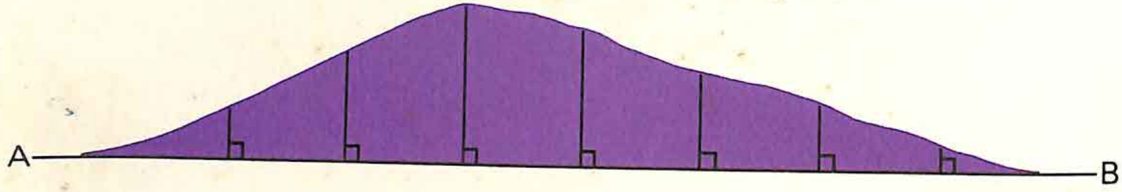
Look at this diagram.



AB is the survey line which does not follow the line of the hedge.

The surveyor makes measurements at right angles from the survey line to points on the hedge. These lines are called OFFSETS

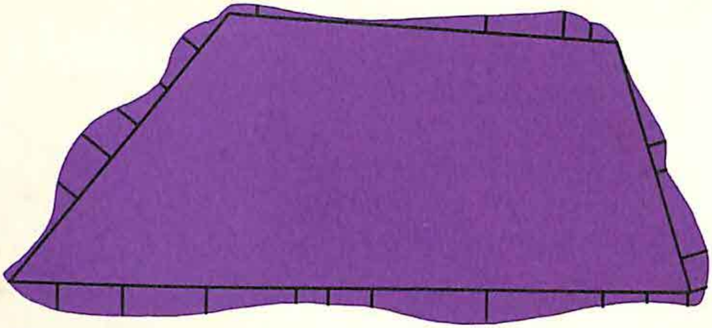
The right angles are estimated.



Here you can see a diagram of a field showing the survey lines and the offsets.

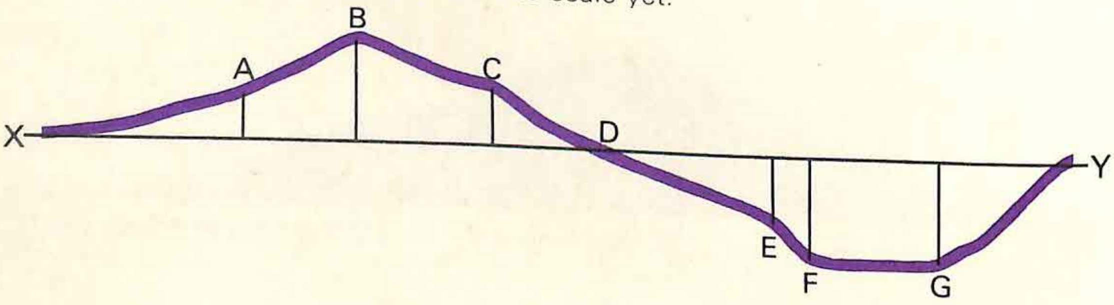
The more bends there are in the boundary the more offsets are needed.

What other measurements must the surveyor have beside the lengths of the offsets if he is to draw the bends correctly on his scale drawing?



The surveyor must measure the distance between the point where each offset takes off and the end of the survey line.

Here is a surveyor's sketch of a footpath showing the survey line and the offsets. It has not been drawn to scale yet.



Here are the surveyor's measurements.

	Y	
	100	
	85	10 G
	75	10 F
	70	6 E
D 0	55	
C 6	45	
B 10	30	
A 4	20	
	0	
	X	

These are read from bottom to top.
Notice the letters X and Y which indicate the survey line.
Offset A is 20 yards along the survey line and takes off to the left.
Some lines take off to the right.

How far along the survey line is offset E and how long is it?

Make a scale drawing of the footpath using a scale of 1 inch to 20 yards. Begin by drawing the survey line to scale and then add the offsets. The path can then be drawn in freehand.

Can you now complete your scale drawing of the field by adding offsets and showing the boundary?

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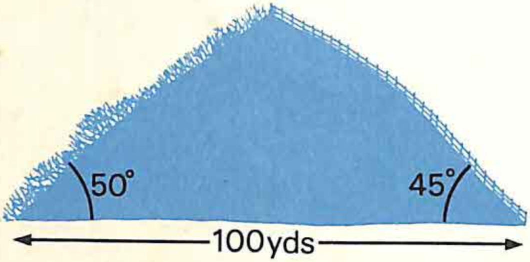
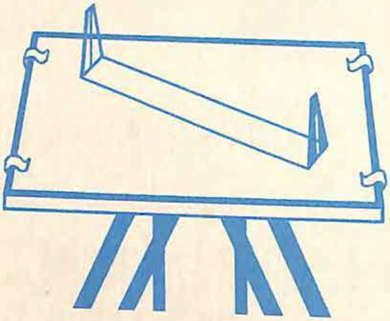
Surveying larger areas

Look at this sketch of a field. Find out if it is possible to make a scale drawing of the field if you know the length of one side and two of the angles. Use a protractor to do this.





In surveying a large area it is not possible to use a chain as the distances are so great and because of obstacles such as buildings which lie in the way. In these cases the angles of triangles are used. There are two ways of doing this.

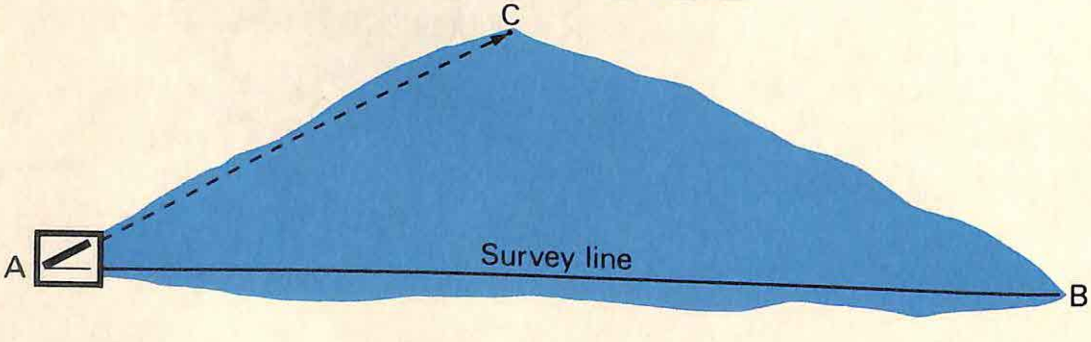
The first is by the PLANE TABLE

This consists of a horizontal board fixed on a tripod, and a sighting rule.

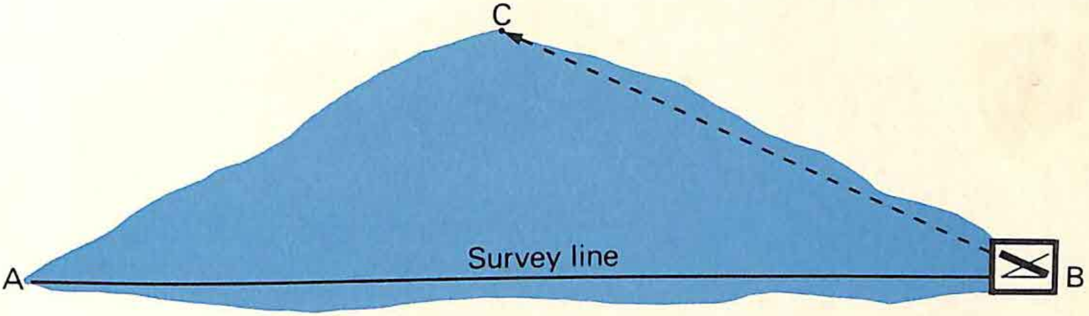
A survey line is marked off with poles and measured.

It is then drawn to scale on paper which is placed on the plane table so that it lies at one end of the survey line. The scale line is lined up with the survey line.

The sighting rule is now pointed at the third corner of the field, which is marked C on the diagram, and a line drawn along its edge on the paper in the right direction.



The plane table is now moved into position over the survey line at point B and the sighting rule is pointed again at C. Another line is drawn. The point where the two lines meet shows the position of C accurately.



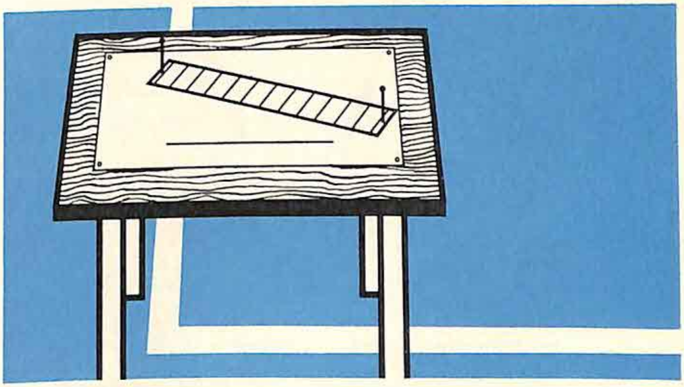
In this method we use angles but do not have to measure them.

You can make a survey of your school grounds by this method.

Measure and mark out a survey line. The side of a football or netball pitch is most suitable. Draw the line to scale.

Set up a drawing board on a stool or table on level ground.

Make a sighting rule from a ruler and two nails.

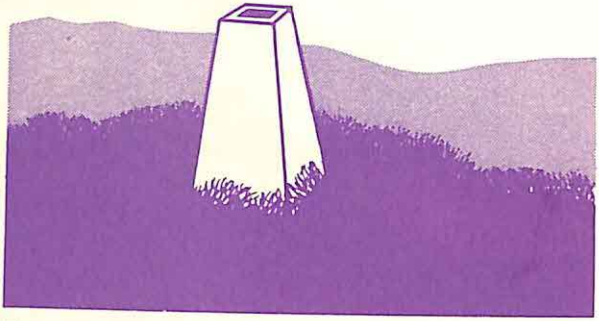


Survey the grounds or yard to show the position of trees, gates, goal posts, buildings, etc.

You can use your scale drawing to calculate the distances between these objects and the base line.

Surveying by measuring angles

Have you ever seen a concrete pillar like this when you have been out in the country?

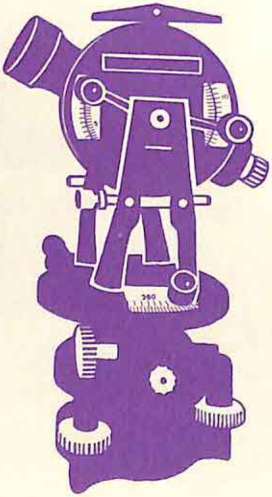


They are usually situated on hills where there is a good view of the landscape and are used by surveyors in map making.

A survey line between two such pillars is carefully measured. Sights can then be taken to other pillars or landmarks and triangles drawn.

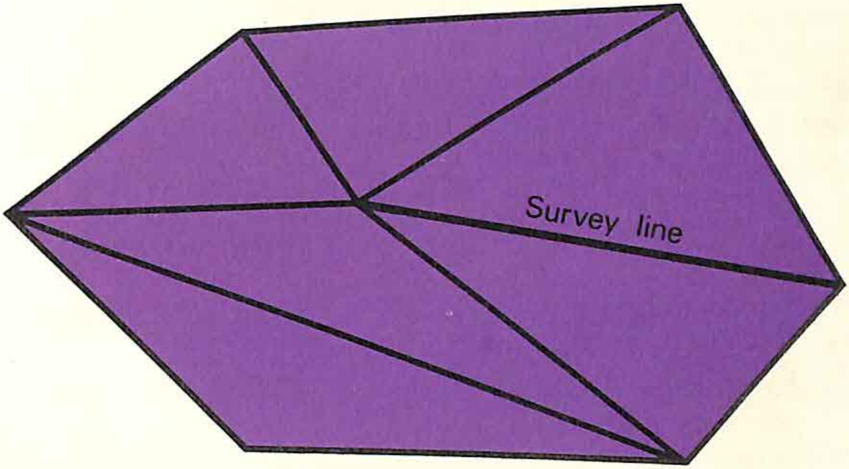
In place of the plane table the surveyor uses an instrument which measures angles from the base line.

The theodolite, as it is called, is really a telescope fixed to a turn-table which is marked off in degrees.



This is a very accurate method of surveying and the popular Ordnance Survey maps were made in this way.

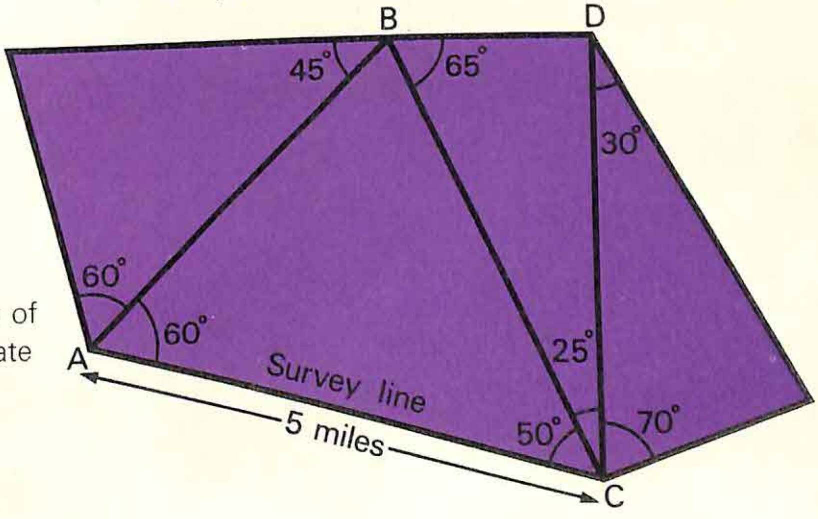
The first maps consisted of a network of triangles, like this.



The pillars are marked on the map like this: △.

Can you find one on the map on page 12? What is its map reference?

Here is a sketch of measurements made on a survey of this kind. Only one length is given.



Make a scale drawing of the survey and calculate the distance between

1) A and B
2) B and D
3) A and D

1 This is a page from a surveyor's notebook showing the survey of a stream.
Make a scale drawing of the stream using a scale of 1 inch to 20 feet.

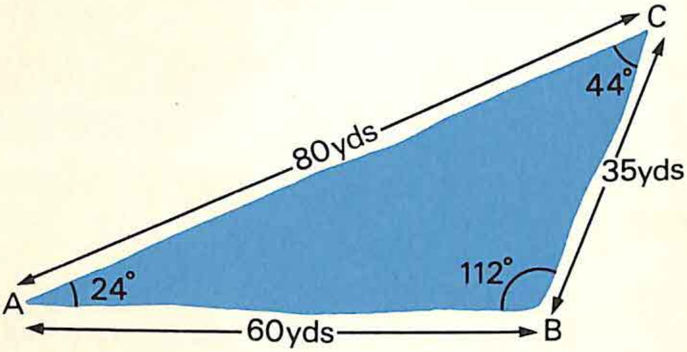
I 0	120	
H 10	100	
G 15	80	
F 5	60	
	45	0 E
	25	5 D
	20	10 C
	10	5 B
	0	0 A

2 Look at this sketch of a field.
You have learned that you can make a scale drawing of a triangular field if you know the length of the three sides or if you know the length of AB and the angles at A and B.
Can you make a scale drawing if you know:

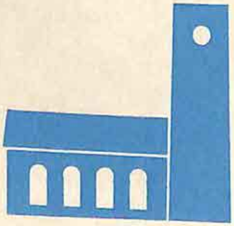
a) the length of AB and the angles at A?

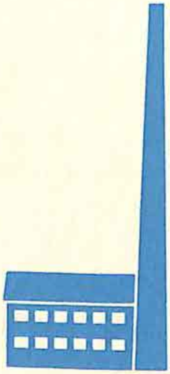
b) the lengths of AC and CB and angle C?

c) the lengths of CB and AB and angle A?

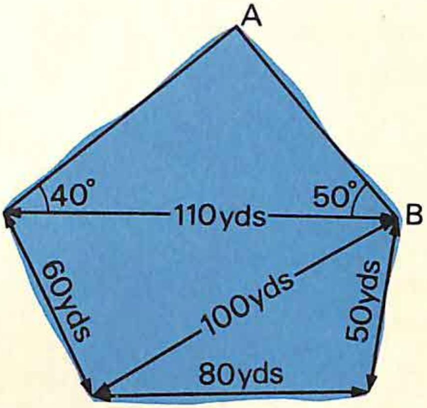


3 Here is a scale drawing showing a factory chimney and a curch, on a scale of $\frac{1}{8}$" to 10 feet.
Which is higher and by how much?

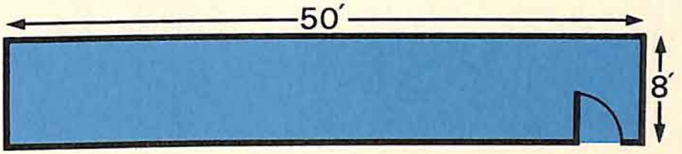


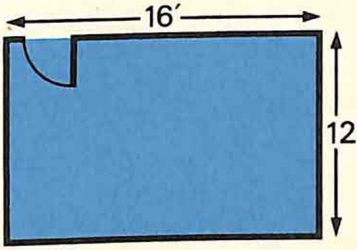


4 The following is a rough sketch of a five-sided field. Make a scale drawing of the field. What is the length of the side AB?

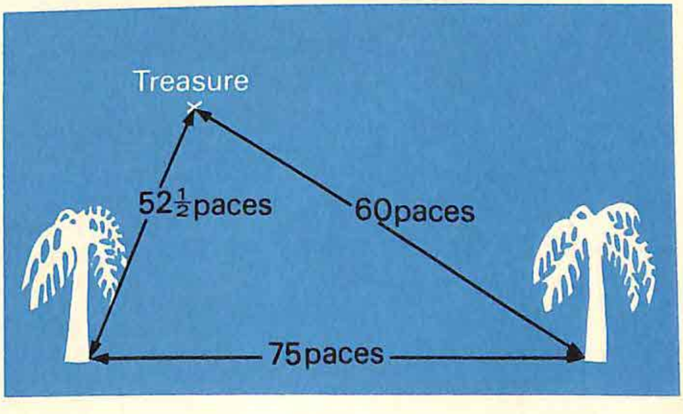


5 On graph paper, make a scale drawing of each of these rooms, using a scale of 1 inch to 8 feet.
Find by counting squares which room has the greater area.



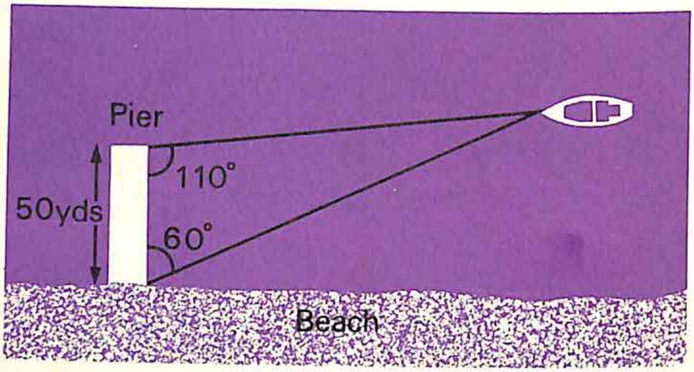


6 A pirate buried his treasure on a desert island. Here is a rough sketch he made to mark the place where he hid it.
Make a scale drawing to show the exact position of the treasure.



7 Draw a triangle ABC with AB 4″ long, AC 3″, and BC 5″.
What is the angle at A?

8 Make a scale drawing to show the position of the lifeboat on its mooring.



Longmans, Green & Co Ltd
48 Grosvenor Street
London W1

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First published 1968

The author has prepared these books with the help and advice of some of the members of the School Mathematics Project who have been introducing new ideas and new spirit into mathematics in the early years of the secondary school course. They feel that some of these ideas and approaches are relevant to children in the primary schools; such children would be thereby more readily equipped for the pattern of the secondary school course which is now emerging. In particular, the author gratefully acknowledges the close collaboration of Mr D J Holding, Principal Lecturer in Mathematics, S. Martin's College of Education, Lancaster, who is one of the principal S M P authors.

Printed in England by Taylowe Ltd., Maidenhead

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